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(54) Method for detecting and locating a break in a synchronous digital hierarchy (SDH) optical link system

(57) A method for detecting a break occurred in an optical link system and quickly and accurately locating the position of such a break. The present invention provides for the use of an alarm indication signal (AIS) of the SDH regeneration section in a non compliant interface of the optical transport network. The basic idea consists in extending the application of the Alarm Indication Signal to the regeneration section of the SDH link layer. With the introduction of the Optical Layer, as lower layer

in the Transport network, the event of the break in a cable as a fault condition in the Regeneration Section of an SDH network is replaced by the cable break event in the transmission section of an optical network. The tributary of the WDM terminal will construct an SDH-compliant Alarm Indication Signal as a result of the break in a fiber or of the reception of a lower or server layer fault signal. As a result, the SDH network manager will not be led in error as to the fault location.

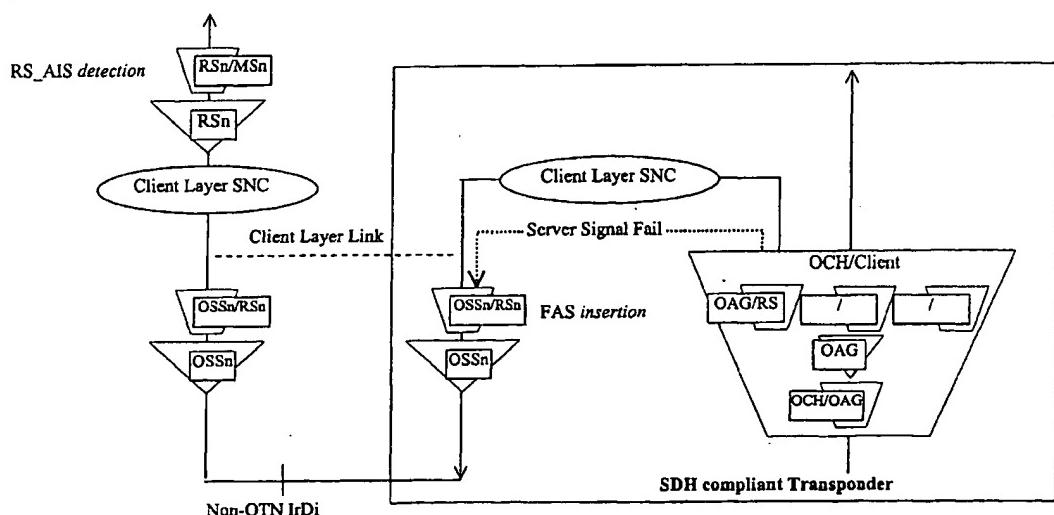


Fig. 3

**Description****DESCRIPTION**

- 5 [0001] The present invention relates to the field of optical networks and in particular is concerned with the detection of failures and breaks in optical lines and related maintenance (restore) thereof.
- [0002] As it is known, one of the outstanding problems in the field of transmission over optical lines arises from the need to assure the reciprocal operation of the various interconnected equipments, specially when such equipments come from different vendors and use different operating systems (multi-vendor network). It is also necessary to be able to detect with comparative facility a break in the line and to intervene in an aimed (i.e. exactly where the break took place) and quick manner for restoring the same.
- 10 [0003] In a multi-vendor optical transport network (OTN) and in SDH (Synchronous Digital Hierarchy) environment the maintenance procedures may be complicated if an Alarm Indication Signal (briefly, AIS) is not generated in the tributary of the WDM (Wavelength Division Multiplexing) terminal as a result of a break in the fiber at the aggregate port. The lack of AIS generation in response to the fiber break may cause problems since the network management systems (OTN and SDH) will be led to an erroneous fault location. In fact, if as a result of the fiber break, a LOS (Loss of Signal) indication is generated in the equipment that manages the network at the optical layer, another false LOS will occur in the equipment that manages the network at SDH layer.
- 15 [0004] Therefore, the main object of the present invention is to improve the fault location techniques in the OTN/SDH networks and the manageability level of the SDH connected to an OTN network.
- [0005] This and further objects are achieved by the method set forth in the independent claim 1. Further advantageous features of the invention are set forth in the dependent claims which, along with claim 1, are to be intended as an integral part of the present description.
- 20 [0006] In practice, the present invention provides for the use of an alarm indication signal of the regeneration section in a non-compliant interconnection interface of the Optical transport network. The basic idea consists in extending the application of the Alarm Indication Signal (AIS) to the regeneration section of the SDH connection layer. Through the introduction of the optical layer, as the lower level of the transport network, the cable break event as a failure condition in the regeneration section of an SDH network, must be replaced with the event of a break in the transmission cable of an optical network.
- 25 [0007] A detailed description of the present invention is now given below by way of a mere exemplifying and non limiting example, and should be read with reference to the attached drawings, in which the various figures show:

- Fig. 1 diagrammatically illustrates a transport network structure;
- Fig. 2 diagrammatically illustrates the optical layer structure;
- Fig. 3 illustrates the interconnection of various administrative domains through a non-compliant OTN interface, the generation of all ONEs and the insertion of the Frame Alignment Signal (FAS);
- Fig. 4 highlights the bytes of the SDH/STM-n Section Overhead;
- Fig. 5 diagrammatically depicts a network section from a transmission end to a reception end in which a break at a low, or optical, layer has occurred; and
- Fig. 6 diagrammatically depicts a network section from a transmission end to a reception end in which a break at a higher layer has occurred.

[0008] Although it is thought that the drawings are thoroughly understandable to a person skilled in the art, a list of the abbreviations, words and acronyms used in such drawings is given below along with an explanation thereof. Subsequently, when it is considered more convenient, the various acronyms and English words will be freely used. Naturally, for a better understanding of the acronyms and abbreviations used in this description, reference should be made to the draft of recommendation G.872.

50 ADM = AIS = Client Layer SNC DXC = Far-end SDH FAS <i>FAS generation</i> <i>FAS insertion</i>	Add-Drop Multiplexer Alarm Indication Signal Sub-Network Connection at Client Layer Digital Cross-Connect Far end of SDH Frame Alignment Signal generation of FAS signal Insertion of FAS
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(continued)

	MSn	Multiplex Section level n
5	Multiplex Section_OH	Multiplex Section OverHead
	Near-end SDH	SDH near end
	Non-OTN IrDi	non compliant OTN Inter-Domain Interface
	OAG	Optical Administrative Group
10	OAM	Operating, Administration and Maintenance
	OCH	Optical Channel
	OCH_NC	Optical Channel Network Connection
	OCH_SNC	Optical Channel sub-Network Connection
	OSSn	Optical SDH Section level n
15	OTHERS	Other clients or other digital transmission structures (ATM, PDH...)
	OTN	Optical Transport Network
	OTSn	Optical Transmission Section level n
	OTU_AIS detection	Alarm Indication Signal detection at Opt. Transm. Unit
	Regeneration Sect._OH	OverHead bytes at Regeneration Section
20	RS_AIS detection	Alarm Indication Signal detection at Regeneration Section
	RSn	Regenerator Section level n
	SDH compliant Transp.	SDH compliant Transponder
	SSF	Server Signal Fail
25	STM-n	Synchronous Transport Module level n
	TMN	Transport Management Network

- [0009] In order to assure the mutual operation between equipments coming from different vendors and used in the connection layer (SDH) the use of transponders is required (see Fig. 1) The object of the transponders is to support both the termination and adaptation functionalities at the ends of the network (Fig. 2).
- [0010] The SDH frame processing at the nodes comprises the operating, administration and maintenance (OAM) functionality in a multi-vendor network. The OAM functions, such as the performance control and the connection test, unavailable in the initial steps of the optical layer strategy, could be implemented in the SDH-compliant transponders where the non intrusive processing of the SDH regenerator section should take place.
- [0011] In particular, as mentioned above, the maintenance procedures in a multivendor environment can be complicated if an Alarm Indication Signal (AIS) is not provided at the interconnection of the various administrative domains (Client layer link) through a non-OTN-compliant interdomain interface (Non-OTN IrDi), Fig. 3, as a result of the break in a fiber or of a general failure in the optical domain or in the remote SDH link in the client layer. The lack of this information can create problems since the network management systems, pertaining to domains of different operators, will be led to erroneously locate the failure by detecting false failure causes and deciding time consuming, unproductive and therefore undesirable actions.
- [0012] In fact, as a result of a failure in the optical domain (Fig. 5) or in the SDH client layer far end link (Fig. 6) a LOS will be detected in the optical layer or in the client layer far end SDH link and several other false LOSs in the near end SDH links in the client layer.
- [0013] As a result, wrong laser turn-off automatic procedures will be activated at each near SDH link in the client layer.
- [0014] The concept which the present invention is based on is that the SDH-compliant transponders, through adaptation functions (Fig. 3) are able to construct an SDH-compliant AIS signal (RS-AIS): in this way the SDH network manager at the near terminal is not induced in error, i.e. false LOS will not be generated. Preferably, the RS-AIS signal is substantially constructed by sending the SDH frame alignment signal plus all ONEs in the remaining bytes of the SDH frame (or at least all ONEs in the J0 bytes), as illustrated in Fig. 4 that shows the bytes of the SDH/STM-n section overhead. The peculiarity of the proposed solution consists in that, in the event of a break, in a cable at a generic point of the OTN network (see Fig. 5, "break 1") or at the far end in the client layer (Fig. 6, "break 2") the same RS\_AIS signal is detected at the near-end SDH level.
- [0015] The main advantage of the solution in accordance with the present invention is to allow for a significant improvement in the fault and break location techniques all over the entire optical transport network and in the manageability level of the SDH connected to the OTN.
- [0016] By analyzing Fig. 5 in more detail it should be observed that, as a result of a break in a cable or of any other

failure in the OTN network, an OTU\_AIS, i.e. an alarm indication signal in the optical transport unit, will be detected (OTU\_AIS detection) downstream of the OTN network; this OTU\_AIS signal is generated by the adaptation function of the optical multiplexing section at the node adjacent to the failure; subsequently an RS\_AIS is constructed as specified above (by sending the SDH frame alignment signal plus all ONEs in the remaining bytes of the frame); then the

5 Frame Alignment Signal is generated (FAS generation); and finally, the RS\_AIS is detected (RS\_AIS detection).

[0017] Analogously, if the failure occurs at the far-end of the client layer, a loss of signal (cLOS) indication will be generated; an SSF/all ONEs will be constructed; a frame alignment signal will be inserted (FAS insertion) and finally, the RS\_AIS will be detected (RS\_AIS detection) at the SDH near-end.

[0018] Therefore, as it will be understood, the solution in accordance with the present invention allows for the transportation, in a transparent manner, of all the RS\_layer signal (and in particular the RSn\_DCC bytes); the RSn trail is not terminated/regenerated at the inlet/outlet of the OTN/SDH network unless in response to a failure. The RSn layer non-intrusive monitoring is possible by monitoring bytes B1, J0 and the SDH frame alignment sync bytes.

15 **Claims**

1. Method of detecting a break in an SDH optical link system and locating the position of such break, for example for maintenance purposes, said system comprising an SDH/OTN network and at least a pair of transponders, characterized in that, in the event of break, an SDH-compliant alarm indication signal (RS\_AIS) is generated by a transponder, which signal is then detected at the near SDH terminal.

20 2. Method according to claim 1, characterized in that said SDH-compliant alarm indication signal (RS\_AIS) is generated by sending an SDH frame alignment signal (FAS) in addition to all ONEs at least in the byte J0.

25 3. Method according to claim 1 or 2, characterized in that said SDH-compliant alarm indication signal (RS\_AIS) is generated by sending an SDH frame alignment signal (FAS) in addition to all ONEs in the remaining bytes of said SDH frame.

30 4. Method according to any of the preceding claims wherein the break occurs inside said OTN network, characterized by the steps of:

- detecting an alarm indication signal in the optical transport unit (OTU\_AIS);
- generating an SSF/all ONES;
- generating a frame alignment signal (FAS); and
- detecting the alarm indication signal in the regeneration section (RS\_AIS) at the near end of the SDH optical link system.

35 5. Method according to any of claims 1-3 wherein the break occurs at the far-end of the SDH optical link system, characterized by the steps of:

- generating a loss of signal (LOS) indication;
- generating a SSF/ all ones;
- inserting a frame alignment signal (FAS); and
- detecting the alarm indication signal in the regeneration section (RS\_AIS) at the near end of the SDH optical link system.

40 6. SDH frame for signaling the presence of a failure or a break in an optical link system for example for maintenance purposes, characterized in that the overhead bytes A1 and A2 represent an SDH frame alignment signal (FAS), at least byte J0, but preferably also the remaining overhead bytes, being all occupied by ONES.

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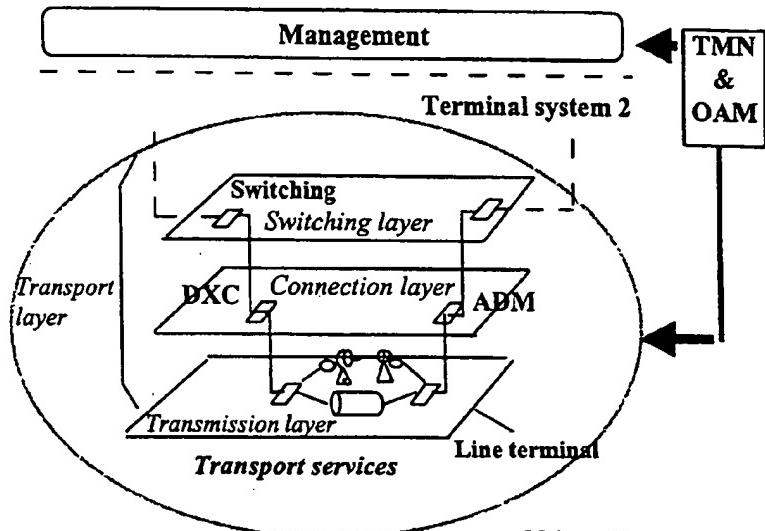


Fig. 1

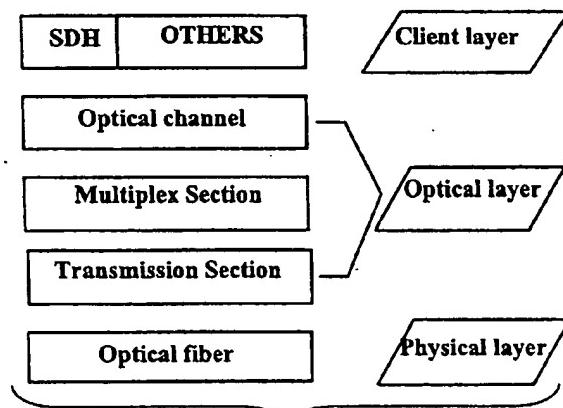


Fig. 2

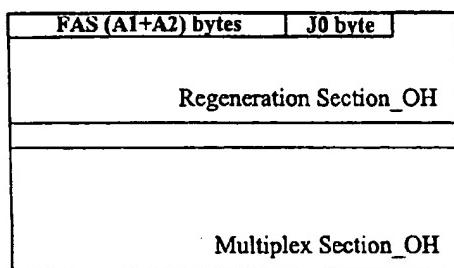


Fig. 4

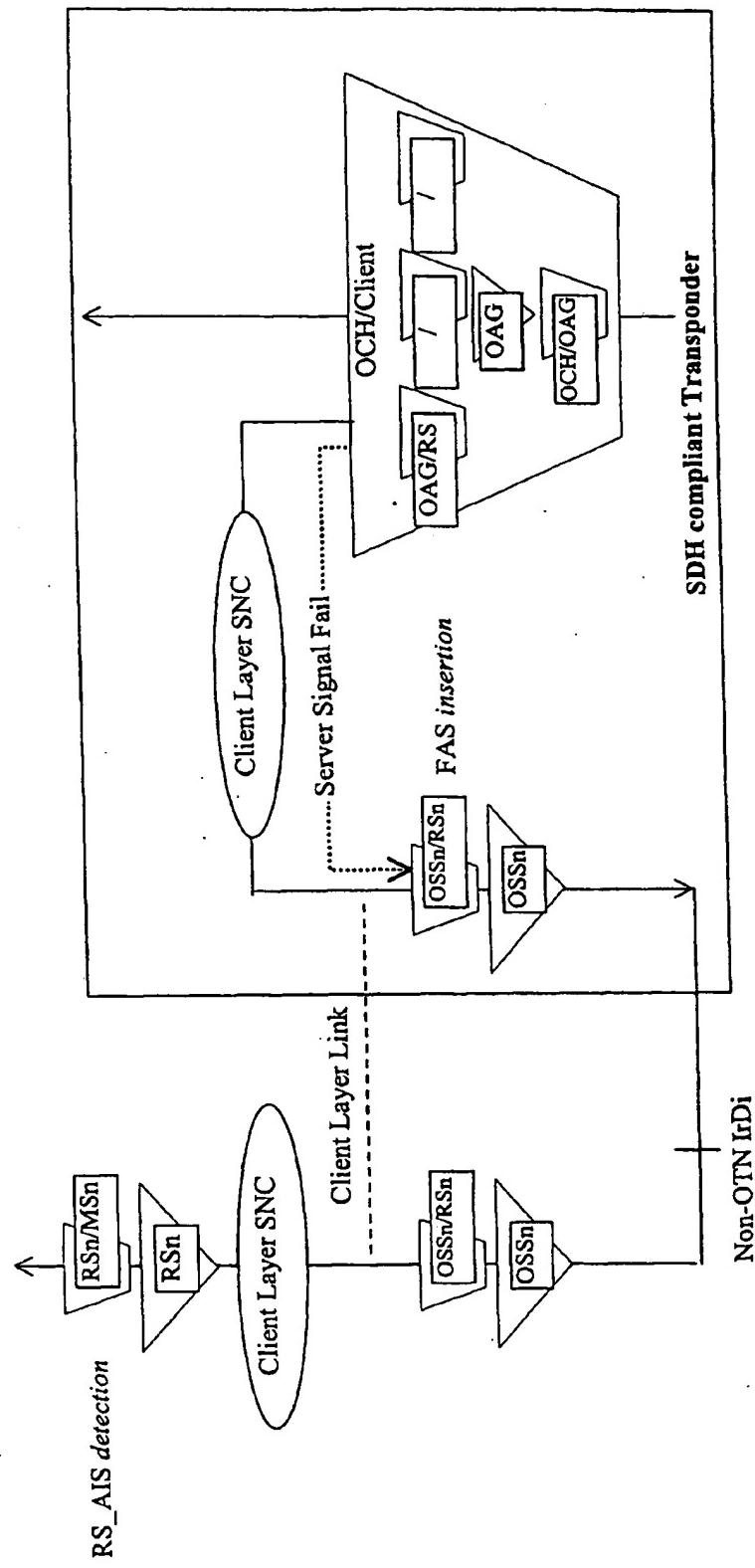


Fig. 3

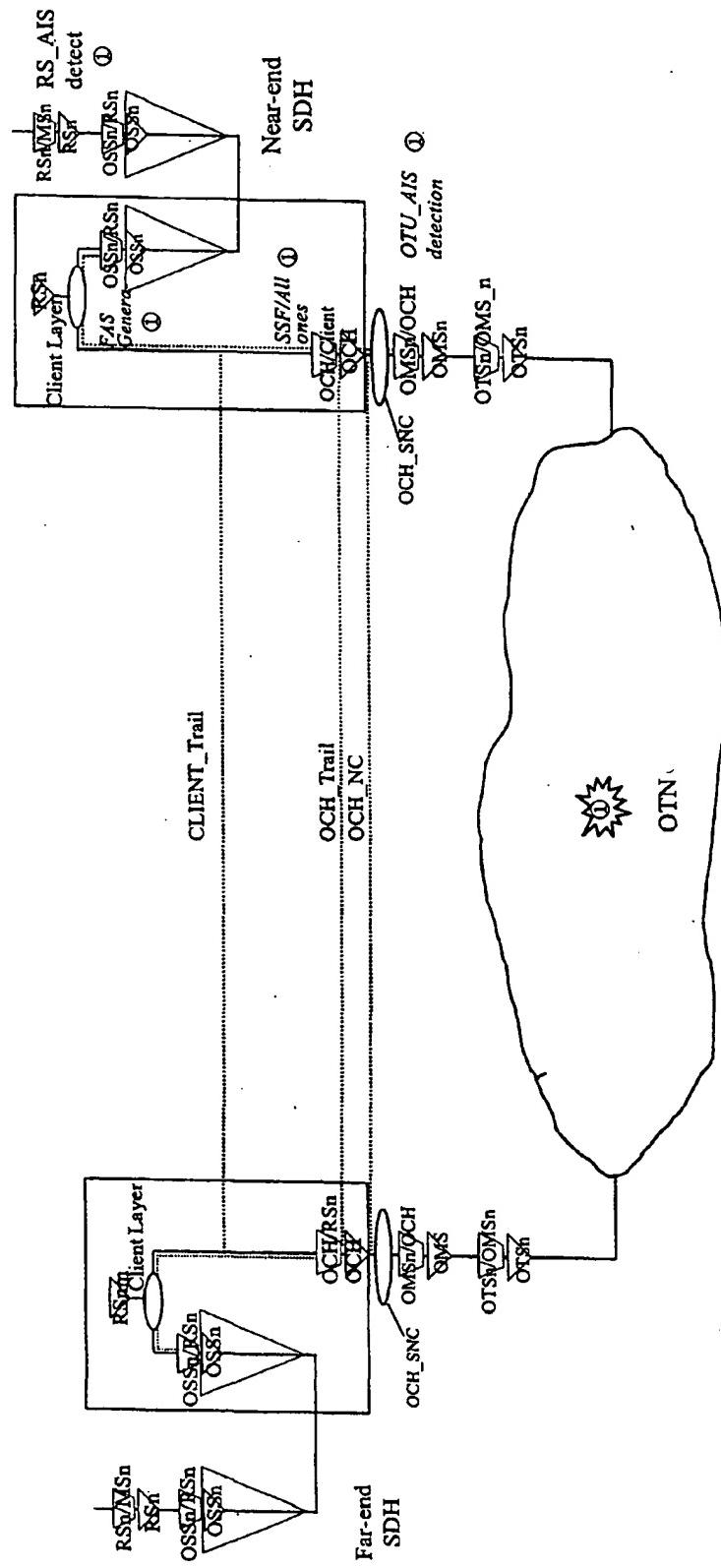
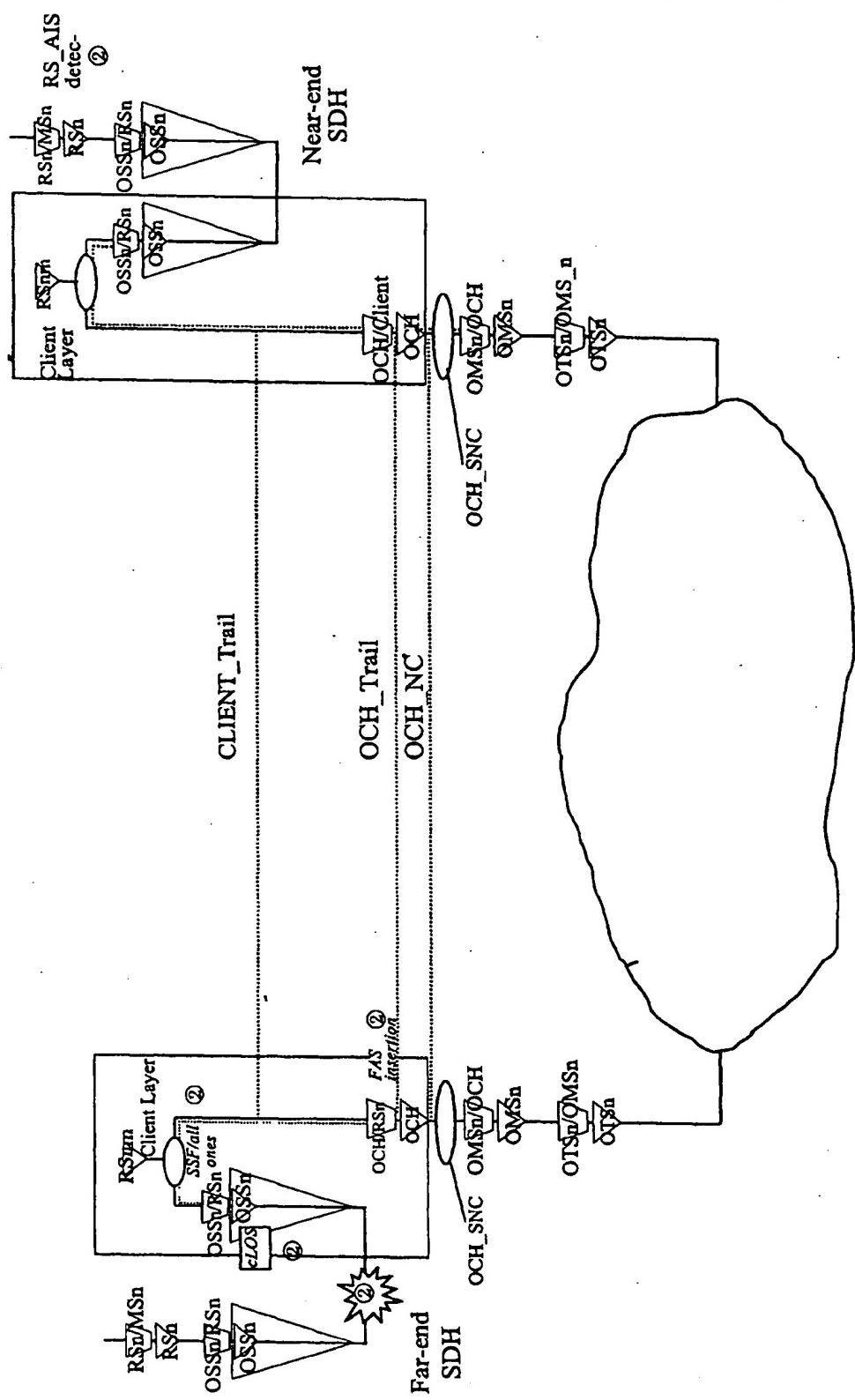


Fig. 5

**Fig. 6**